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Climate Change, Vulnerability, Food Security and Human Health in Rural Pakistan: A Gender Perspective

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A□STRACT

The study primarily focused on mapping farm households' vulnerability index and to identify gender differentiated determinants of vulnerability, food security, and health vulnerability. PCA has been applied to generate vulnerability indices by combining different socioeconomic and climatic factors. The study uses data of Climate Change Impact Survey [CCIS (2013)]. The results indicate that high vulnerability to climate change prevails in the study area. Further, the results obtained from descriptive, and ordered Logit, and binary Logit/Probit regression models are suggestive that those households where females are empowered through decision making, entitlement to inheritance, are more educated, and can participate in social gatherings and are allowed to visit hospital are found less vulnerable as compared to male dominant families. Moreover, female empowerment makes farm households more food secure, and lesser vulnerable in terms of health vulnerability. The study also observes the gender specific perceptions to climate change, and findings reveal that male and female decision makers are found perceiving climate change and having some significant differences regarding perceptions.

□*eywords:* Climate Change, Food Security, Health, Gender, Household Vulnerability

I. INTRODUCTION

Issues of climate change and variability have received overwhelming attention the world over during the last decade. A number of phenomena are occurring simultaneously including increase in average temperature; erratic precipitation coupled with its uneven distribution; increase in both frequency and intensity of extreme weather events; melting of glaciers and snow; and sea level rise. These happenings are affecting the natural ecosystems with major consequences for several weather sensitive sectors (agriculture, forestry, water resources and coasts) posing serious threats to livelihoods, food security, human health and human settlements. A growing consensus is that climate change cost shall fall heavily on the poor and marginalised communities being their more vulnerability coupled with poor adaptive capacity due to lack of access to resources required [Herrmann, *et al*. (2005)]. Climate change shall aggravate already existing high poverty.

The women, children and elderly make up a disproportionate share of poor people (Terry, 2009), and are more likely to be affected differently in the context of worsening the poverty and existing inequalities. Buechler (2009) citing Lambrou and Piana (2006) argues that low-income women in agricultural communities are among the world's poorest people—the most vulnerable to negative impacts of climate change.

South Asia, one of the most vulnerable regions in the world, is known to be the most disaster prone area that accounts for 80 percent of the total affected population and 86 percent of total damage due to droughts [Spijkers (2011)]. This region is the home of world's one-fifth population, has the highest concentration of world's poor (40 percent) and houses 45 percent of the world's undernourished population. Climate change projections have shown that the temperature in the region would rise by 3–4°C by the end of 21st century [Spijkers (2011)] and the occurrence of extreme events would intensify.

Pakistan is among the most vulnerable countries in the South Asian region given still overwhelming dependence of its population on agriculture which in turn mainly depends on the Indus Basin River System. The intensity and frequency of extreme climate events have increased in Pakistan during the recent decades—river flooding has occurred each year in one or the other part(s) of the country during the last six years (2010 to 2015). The country experienced its longest drought of 1997-2001. These events have caused damages of worth billions of dollars. The Taskforce on Climate Change in Pakistan has indicated that the situation is going to get worsen in coming decades because the temperature increases in the country are expected to

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be higher than the global average resulting into disruption in agriculture and other supportive ecosystems and population displacement [Pachauri and Reisinger (2007)] that would seriously affect agricultural production and livelihood of the masses. Therefore, one of the major anticipated challenges for the Pakistan's economy would be ensuring food security to rapidly increasing population in coming decades. The studies have predicted 5–7 percent decline in wheat yield with 1^0C increase in temperature [Ahmad, *et al*, (2014)].

Agricultural production in Pakistan largely relies on irrigated farming which accounts for more than 90 percent of food and fibre and most of the fodder production. It is widely accepted that climate change would directly affect the availability and distribution of water in the future. During the next 50 years, Western Himalayan glaciers are projected to melt significantly, and this will be accompanied by increased rainfall thus further increasing frequency of flooding of the rivers. However, subsequently the river flows and rains would diminish adversely affecting production of food and other crops thus adding to food insecurity and poverty in Pakistan.

In rural Pakistan, women and elderly are likely to suffer the most from adverse impacts of climate change as majority of them are engaged in/dependent on agriculture which is highly climate sensitive. Women and children are already an 'underpaid, overworked and exploited resource' and climate change will further increase this workload and accentuate their vulnerability. Yet, the gender vulnerability is one of the most ignored areas in the climate research [Kakota, *et al.* (2011)].

In flood, and drought-prone areas of Pakistan, seasonal migrations of human and livestock populations to other regions are a common phenomenon. These migrations are either partial or complete depending on the severity of weather or climatic events. Women play central roles during such movements in terms of occupational diversity, food production, preservation and storage. The diversified mechanisms practiced by women include managing livestock, poultry, and vegetable production as coping strategies during calamities. For instance, in arid ecologies women preserve surplus milk and vegetables produced during the summer season for use during harsh winters. Similarly, in desert ecologies women and children stay back at home while managing few animal heads as food security while depending upon preserved feed and conserved rain water in wells.

Climate change also affects human health through various channels including, in major, climate hazards/shocks like heat and cold waves, extremes of precipitation—floods and droughts, storms, air pollution and infectious diseases [Patz and Kovats (2002)]. The adverse health impacts would generally occur in poor population having little capacity to cope with or to adapt to impacts of climatic factors. Any region or population that is already suffering from climate stresses (particularly from the extremes like floods and droughts) socioeconomic stresses and lack health infrastructure are at more risk of health impacts of climate change [Patz and Kovats (2002)].

The extent of vulnerabilities depends on seasons; age and gender of individuals; and characteristics of households, communities, and regions. It is reported that exposure to hazards varies across individuals depending on their roles and responsibilities [Kakota, *et al.* (2011)] that expose them to different climatic risks and access to resources resulting into varied adaptive capacity to respond to the risks of climate changes and variations—leading to varied vulnerability of members of even the same household including men, women, children and elderly, to the adverse impacts like health and food security.

Adequate attention has not been paid to local dynamics and underlying vulnerabilities as well as the gender level disaggregated impacts and as a result empirical evidences on the issues are scarce. It is crucial to analyse and understand these issues in order to formulate evidence based policy and devise coping strategies. There is a debated consensus that the higher inclination and activation of women towards pro-environment behaviour and significance of their influence in domestic affairs through roles played by them in household management and as an educator of other family members makes it vital to design gender-sensitive strategies for adaptation and mitigation of climate change. Therefore, women's interest and a gender lens needs to be incorporated and should be a prerequisite to effectively address the climate change impacts [Solar (2010)].[1]

Like elsewhere in the world, the complex and dynamic relationships among climate change, agriculture, food security and health and how these affect men and women differently are not conclusive and remain least understood in Pakistan. Due to scarce gender-disaggregated data, there has been limited research on how men and women adapt to climate variability and change to maintain their livelihoods, and food security as well as health. A lot is being discussed and argued on these issues; however, no noteworthy empirical research has been found in the literature.

A huge body of literature [Adger and Kelly (1999); McCarthy, *et al*. (2001); Intergovernmental Panel on Climate Change (2001); Fussel (2007); Paavola, (2008); Deressa, *et al*. (2008); Hahn, *et al*. (2009); Yuga, *et al*. (2010); Opiyo, *et al*,. (2014)] concentrates on vulnerability index for rural households. However, little attention has been paid in Pakistan and only few studies have mapped vulnerability regarding flood hazards [Mustafa (1998 & 2005); and Mustafa, *et al.* (2010)] and constructed district wise vulnerability index [Malik, *et al*. (2012) and Rehman and Sulman (2013)]. This study contributes to the existing literature regarding Pakistan by constructing overall vulnerability index, health vulnerability index, and food vulnerability index and other vulnerability indices using gender and age differentiated data on important factors.

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[1]In 1991 cyclone in Bangladesh, 90 percent of the total deaths included women [Solar (2010)].

The Climate Change Impact Survey (CCIS), 2013 data collected under PIDE-IDRC project[2] provides opportunity for analysis of gender specific perceptions about climate change and explore the household level gender as well as age differentiated health impact of climate change and variability. This research is mainly aimed at exploring the impact of climate change and gender differentiated socio-economic factors on household vulnerability as well as food security. The more specific objectives of the study are to:

- analyse gender specific perceptions about climate change;
- construct household vulnerability index and explore the impact of climate change and gender differentiated socio-economic factors on household vulnerability as well as food security; and
- Evaluate the household level gender and age differentiated health impacts of climate variability.

II. SOURCE OF DATA AND METHODOLOGY

The study is based on Climate Change Impact Survey (CCIS), 2013 data collected from 3430 farm households located in 16 districts of Pakistan representing all the major cropping systems and various categories of farms by tenancy and size. A survey schedule consisting two parts – a questionnaire for males and a questionnaire for females was used to record information about the same household. The questionnaire for males encompasses information regarding farm characteristics, production practices, and questions relating to farmers' knowledge/perceptions about climate change and copping strategies adopted. The survey schedule for females covers questions regarding family profile, education, employment status and farm/non-farm incomes generated by each family member, ownership of durables, consumption, perception of female respondents of the same household about climate change and its impact on human lives and copping strategies adopted, male and female members who suffered weather related diseases etc. The data on climatic variables was obtained from Pakistan Meteorological Department (PMD), Islamabad and was mapped with the household data using village level longitude and latitude information. This study uses data of 3427 farm households after dropping three observations on account of missing values.

The impacts of climate change on vulnerability, health, and food security have been analysed by a number of studies including Hoddinott and Kinsey (2000), Archer (2003), Kovats and Hajats (2008), Ahmad and Fajber (2009), Jungehulsing (2010), and Rakib (2014). Other studies including Daressa, *et al*. (2008), Hahn, *et al*. (2009) and Opiyo, *et al*. (2014) analysed the factors affecting vulnerability of households in developing countries. These studies

[2]The survey was conducted during 2013 by PIDE under the IDRC sponsored project "Climate Change, Agriculture, and Food Security in Pakistan: Adaptation Option and Strategies".

constructed vulnerability indices either combining various indicators by assigning equal weights [Hahn, *et al*. (2009)] or used Principal Component Analysis (PCA) technique to generate the index [Opiyo, *et al*. (2014)].

The present study closely follows Hahn, *et al.* (2009) and Opiyo, *et al*. (2014) to construct vulnerability index and to identify its gender specific determinants. The details of various indices constructed and the constituent factors are given in the following.

Vulnerability Index:

The index is constructed by combining six sub-indices by applying Principal Component Analysis (PCA). The sub-indices, comprising socio-economic variables and climatic factors, included socio-demographic profile, livelihood strategies, food vulnerability, social network, health vulnerability, and climatic variability.

It is important to note that these indicators are normalised between 1 and 0 to make them unit free by using following formula adopted by UNDP to construct human development index and also used by Hahn, *et al.* (2009).

$$I_i = X_i - X_{min} \,/\, X_{max} - X_{min} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Here, I_i is standardised indicators, X_i is original indicator i whereas X_{max} and X_{min} are respectively minimum and maximum values of the relevant indicator. The construction of these sub-indices using the normalised indicators and the details of the constituent indicators are given below:

Socio-demographic profile is constructed by combining through PCA the indicators namely dependency ratio, lack of education, female ratio, distance of boys primary school, distance of girls primary school, and female entitlement to property. Livelihood strategies vulnerability index combines indicators namely lack of non-farm income, crop diversification, herd size of livestock, and size of operational land holdings. The social networking vulnerability index is generated by combining distance to extension, lack of access to formal loan, social interactions, and lack of support from government. The food vulnerability index is constructed by combining three indicators namely daily calories intake, having faced difficulties to feed family members during last twelve month, and sources of food supply. Health vulnerability index comprises sources of drinking water, distance to Basic Health Unit, number of family members suffered from diseases, ratio of treated to ill members, toilet facility, and female permitted to visit dispensary/hospital. The climate variability index combines through PCA the 20 years averages of temperature and precipitation for Rabi and Kharif season and deviations of long run norm of temperature and precipitation from current values of the climatic variables (temperature and precipitation) for the respective seasons.

Description of Various Indicators Used in Construction of Sub-Indexes:

The study would construct vulnerability index from six sub-indexes because formulating a composite vulnerability index including all the indicators simultaneously may give too small weights to have any worth. A number of indicators were used to construct the above mentioned sub-indices of vulnerability. The indicators used for each of the sub-index are defined in the following (or see Table 2 in appendix).

Socio-Demographic Profile Index:

Dependency Ratio: It is calculated by dividing the sum of numbers of family members in age groups below 15 years and above 64 years by number of family members having ages between 15 to 64 years as used by Hahn, *et al*. (2009). Higher the dependency ratio, the higher would be the vulnerability level of the household.

Female Ratio: It is calculated by dividing the number of female members of a household by size of the family. A household with higher proportion of females may be more vulnerable Hahn, *et al.* (2009).

Females' Entitlement to Property: It is a dummy variable which takes value of one (1) if the females in a households lack entitlement to property and zero (0) otherwise. If the females are not empowered or lack entitlement to property rights, these females can be vulnerable.

Lack of Primary Education: It is measured as total numbers of household members having age above 14 years but had not completed primary level education. Low education level in a family may lead to higher vulnerability.

Distance to Boys and Girls Primary Schools: Distance to boys as well as girls primary schools measured in kilometers. The distance to schools especially to Girls School is very important indicator as most of the females are not allowed to enroll in distant schools due to local customs, social taboos, and even lack of financial resources.

Livelihood Strategies:

*Lack of Non-Farm Income***:** The variable is a dummy which takes a value of one (1) if the farm household do not have non-farm income source and zero (0) otherwise. Farmers who lack income from non-farm sources are expected to be more vulnerable and especially more prone to shocks.

Crop Diversification: It is calculated as deviation of Hefindahl Index (HI) from 1. The HI is defined as sum of squares of the acreage proportion of each crop in total cropped area. The value of crop diversification index ranges between 1 and zero where zero suggests complete specialisation and closer to 1 suggests more diversification. The normalised crop diversification indicator was reversed by subtracting it from one (1). The value for the resulting indicator closer to zero would reflect more diversification and those closer to one would

show complete specialisation. This study supposes that crop diversification enhances income of farmer and makes him less vulnerable and vice versa.

Livestock holding: It represents the livestock herd size expressed as adult cow equivalents. The weights used for conversion of each species of animals into cow equivalents are given in Appendix (see Table 1).The inverse of livestock holding is used as a determinant of livelihood vulnerability.

Size of Operational Land Holding: It measures the difference of normalised size of operational land holding in acres from one.

Social Networking Vulnerability

Distance to Extension Office: It represents the normalised distance to office of the extension department in kilometer. The value closer to one shows higher vulnerability.

Lack of Access to Formal Loan: It is a dummy variable which takes value of one (1) if the households have no access to formal loans and zero (0) otherwise.

Social Interactions: It is measured as the ratio of number of times a household got help[3] from others during 2012-13 to the number of times a household helped others in farm operations and marketing activities etc.

Lack of Support from Government: The indicator is a binary variable assigned a value equal to one (1) if households did not receive support from government during 2012-13 and zero (0) otherwise.

Food Vulnerability

Per Capita Daily Calories Intake: It is calculated by dividing total calories[4] consumed by family size measured in adult equivalents.[5] The households with per capita calorie intakes of less than 2300 Kilocalories are considered as food vulnerable. The normalised indicator was reversed by subtracting it from one and the value of reversed indicator closer to one would indicate higher food vulnerability.

Difficulties in Feeding: The calculation of this indicator is based on response of the household to the question that whether they faced difficulties to feed their family members during various months of the year 2012-13? The

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[3]In the form of manual labour, machinery, implements, inputs, outputs and money borrowing etc.

[4]Total calories are calculated by multiplying food consumption in grams with kilocalories obtained from respective food commodities and information about calories are obtained from table entitled "Food Composition Table for Pakistan" composed by the Department of Agricultural Chemistry and Human Nutrition, Agricultural University, Peshawar in 1985 with the collaboration of Ministry of Planning and Development, Government of Pakistan.

[5]Family size in adult equivalent has been calculated by multiplying different age groups with weighted male adult equivalent calories recommended for the Pakistani population.

response of households for each month was recorded in the form of a binary variable having value equal to one (1) if difficulty was faced and zero otherwise. The indicator is calculated by dividing total score of difficulties (during 2012-13) by 12, thus it ranges between zero and one. A value close to one shows high food vulnerability.

Sources of Food Supply: The indicator is constructed on the basis of sources of food supply availed or would be available to the household in case of shock(s). These sources included self-sufficiency from family farm (cropping and livestock), buy from market, obtained in exchange of labour, and borrowing from neighbour/relative/friend and were respectively assigned a weight of 0, 2, 3, and 5 to match a higher weight with higher vulnerability. The average score of each household was calculated by dividing the total scores by the number of food supply sources availed/available to that household. The average scores were normalised to find out the indicator of sources of food supply. A value of normalised indicator close to one reflects higher food vulnerability.

Health Vulnerability

Source of Drinking Water: The construction of this indicator is based on the sources of drinking water available to the households. The sources of drinking water included piped water, motor pump, hand pump, covered well, and open well and were scored as 1, 2, 3, 4, and 5 respectively to make higher value reflecting higher vulnerability. The indicator was calculated by normalising the scores. A value of the indicator closer to one reflects higher vulnerability.

Type of Toilet: Five types of toilet facilities were available in the study area. These included flush connected to public sewerage, flush with pit, open drain, dry latrine, and no toilet. These types were respectively assigned scores of 1, 2, 3, 4, and 5. The scores were normalised and to find out the indicator. A value of the indicator closer to one indicates higher health vulnerability.

Total Number of Ill Members: This variable was constructed by normalising the number of family members that suffered from disease(s) during 2012-13. A greater number of ill members in a family reflects its higher vulnerability.

The Ratio of Treated to Total Ill Members: It is calculated by dividing the total treated members with total number of members suffered illness during 2012-13. The ratio of treated persons was reversed by subtracting it from one. A value closer to one indicates high health vulnerability.

Distance to Basic Rural Health Units: The indicator is normalised distance of basic health unit in kilometers from the village of residence of household. A value of the indicator close to one reflects higher health vulnerability.

Females Permitted to Visit Health Facilities: The indicator is a dummy variable which takes a value equal to one (1) if the females of respondent family are allowed to visit hospitals, basic health units, and dispensaries alone and zero (0) otherwise.

Climatic Variability Index:

Averages of Temperature: These indicators are normalised averages of the mean temperature of last twenty years during the Kharif and Rabi seasons of 2012-13.

Precipitation: These indicators are also normalised averages of the precipitation received during the last 20 years in the Kharif and Rabi seasons of 2012-13.

Deviations of Temperature: These indicators are the normalised deviations of current seasons (Kharif and Rabi of 2012-13) temperatures from the respective long run norms (average of last 20 years).

Deviation of Precipitation: These indicators are the normalised deviation of current season's mean precipitation received during Kharif and Rabi seasons of 2012-13.

Food Security Index

Construction of household Food Security Index and to explore the impact of climate change and gender differentiated socio-economic factors on household level food security is one of the important objectives of this study. For this purpose, food security index covering two important components of food security namely availability and accessibility was constructed by combining five indicators through PCA. These indictors included size of livestock holding, daily calories intake, crop diversification, and food supply sources by using PCA. The definitions and description of these indicators has been discussed in the previous section. The weights obtained from principal component analysis are listed in following table.

Table 3

Weights of Different Indicators of Food Security

Food Security Indicators	Weight (W)	Food Security Indicators	Weight (W)
Food Feeding Difficulties during Last Twelve Months	0.1745	Sources of food supply	0.1290
Per Capita Kilocalories per day Intake	0.2828	Crop Diversification	0.1200
Livestock Holding (cow adult equivalent score	0.2937		$\sum W = 1$

Source: Author's own calculation.

Categorisation of Households based on Vulnerability Indices—IPCC Framework

Following the framework of Intergovernmental Panel on Climate Change (IPCC), we have also constructed three major components of vulnerability namely Adaptive Capacity, Exposure, and Sensitivity. Adaptive Capacity index comprises Socio-Demographic Profile, Livelihood Strategies, and Social Networking combined through PCA. The exposure index is the same as the climatic variability. The sensitivity index comprises health vulnerability and food vulnerability indices combined through PCA.

Following the IPCC, we defined vulnerability= Adaptive Capacity-(Exposure + Sensitivity) i.e. vulnerability is equal to adaptive capacity minus sum of Exposure plus sensitivity. Using this definition of vulnerability and the calculated component indices, households are categorised into three major groups i.e. less vulnerable, moderately vulnerable, and highly vulnerable. The first, households which have adaptive capacity > (exposure + sensitivity) were categorised as less vulnerable reflecting a situation where the household is vulnerable but can still cope adverse situations. The second, households with adaptive capacity= (exposure + sensitivity) were categorised as moderately vulnerable where they need urgent but temporary assistance to move out of adverse situation. The third, households with adaptive capacity < (exposure + sensitivity) are categorised as highly vulnerable, suggesting a situation where a household would be at a point or situation of no return. Households are unable to escape themselves from adverse shock [Hahn, *et al.* (2009); Opiyo, *et al*. (2014)]. We found only two categories of households i.e. less vulnerable and highly vulnerable among the sampled households and were assigned value of 1 and 2 respectively.

Impact of Climate Change and Gender Differentiated Factors on Household Vulnerability

The categorisation of households into less vulnerable (1) and highly vulnerable (2) resulted in a binomial dependent variable of vulnerability. Therefore, to observe gender differentiated impacts on household vulnerability, this study has employed Ordered Logit/Probit model owing to aforementioned categories of vulnerability as used by Opiyo, *et al.* (2014) to find out the determinants of vulnerability in Ethiopia. By following Greene (1997), the reduced form of Ordered Logit model is given as below:

$$Y_i^* = X\beta + u_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Where Y is level of vulnerability or resilience of households and it is an ordered outcome and Y=1 the household is less vulnerable and it has ability to show resilience Y=2 stands for highly vulnerable household. Moreover, X is a vector

of independent variables, and β is vector of parameters and u_i is error term that contains hidden information. The independent variables include composition of family by age as well as by gender, ratio of educated females to total number of female members of a family, females' entitlement to inheritance (land/property), family females permitted to participate in social events, family females permitted to visit dispensary, decision made by male, decision made by females, participation of family male(s) in non-farm activities, participation of family females in non-farm activities, distance of basic health unit , distance of girls primary school, access to formal loans, and government support, and climatic variables (temperature in Rabi and Kharif seasons precipitation in Rabi and Kharif seasons, and deviations of temperature and precipitation from the long run averages. These variables are briefly described in the following table:

Table 4

Definitions of Variables

Variable Name	Definition of Variable
Vulnerability	Less vulnerability=1 and highly vulnerable=2
Food security	Binary variable i.e. food security=1 and otherwise food insecurity=0
Health Vulnerability	Index constructed on the basis of six indicators is a continuous variable
Female education ratio	Number of educated females divided by total number of females in a family
Age Group (below 15 years)	Binary variable i.e. if family have members in age group below 15 years =1 and otherwise=0
Age Group (16-30 years)	Binary variable i.e. if family have members in age group between 16-30 years =1 and otherwise=0
Age Group (31-40 years)	Binary variable i.e. if family have members in age group between 31-40 years =1 and otherwise=0
Age Group (41-60 years)	Binary variable i.e. if family have members in age group between 41-60 years =1 and otherwise=0
Age Group (above 60 years)	Binary variable i.e. if family have members in age group above 60 years =1 and otherwise=0
Tenant	Dummy variable takes value equal to one if the farmer is a tenant operator and zero otherwise
Owner-cum-Tenant	Dummy variable where for owner-cum-tenant=1 otherwise zero
Owner	Dummy takes value equal to 1 if the farmer has title to all the land he operates. It is used as the reference category in the regression analysis
Property Rights for Females	Dummy variable taking value of one (1) if the females of the family have right of entitlement to land/property and zero otherwise
Females Social Participation	Dummy variable where 1 is assigned for household which allows their females to join social activity otherwise zero
Females Permitted to Visit Health Facilities for Treatment	Dummy variable where 1 is assigned for household that allows their females to visit dispensaries/basic health unit/doctors/hospitals and zero otherwise.
Male Non-Farm	Dummy variable if only male member is participating in non-farm activity=1 otherwise zero
Female Non-Farm	Dummy variable if only female member is participating in non-farm activity=1 otherwise zero
Farm Experience	Total number of years farming experience
Decision by Male	Dummy variable if decision made by only male=1 otherwise zero
Decision by Female	Dummy variable if decision made by only female=1 otherwise zero
Loan Access	Dummy variable if households having access to loan=1 otherwise zero.
Help from Government	Dummy variable if households received government's help=1 otherwise zero.
Distance to Girls Primary School	Distance of girls primary school in KM
Distance to Boys Primary School	Distance of boys primary school in KM
Distance to Basic Health Unit	Distance to basic health unit in KM
Average of 20 Years Temperature Rabi season	Mean temperature
Average of 20 Years Temperature Kharif season	Mean temperature
Average of 20 Years Precipitation Rabi season	Mean precipitation
Average of 20 Years Precipitation Kharif season	Mean precipitation
Deviation 20 years Rabi Temperature	Mean deviation
Deviation 20 Years Kharif Temperature	Mean deviation
Deviation 20 Years Rabi Precipitation	Mean deviation
Deviation 20 Years Rabi Precipitation	Mean deviation

Impact of Gender Differential Factors on Food Security, Health Vulnerability, and Adaptive Capacity

To estimate the gender differential, and some climatic determinants of food security, the study uses binary Logit model otherwise zero. Binary food security dependent variable is regressed on same explanatory variables as used in the case of Ordered Logit model to estimate determinants of vulnerability index.

Similarly, to find out the impact of gender differential factors and climatic factors on health vulnerability, study uses Ordinary Least Square (OLS) because we have dependent variable in continuous form. The higher the value of vulnerability index, the higher the vulnerability will be. Further, we will find out the factors determining adaptive capacity of rural households.

III. RESULTS AND DISCUSSION

One of the main objectives of this study is to map vulnerability index and decompose it regarding gender differential, some socio-economic variables, and climatic factors. This research has applied descriptive analysis and analytical techniques such as ordered logit model, binary logit model, and ordinary least square regression to identify the determinants of vulnerability, food security, and health vulnerability respectively. The results of the analyses are presented and discussed in the following.

The results show that almost 34 percent male decision makers perceive that there is an overall increase in rainfall in their area whereas about 32 percent female decision makers perceive an increase in the rainfall. A greater percentage of female decision makers (63 percent) perceive that rainfall has declined in their area as compared to their male counterparts (59 percent). A vast majority of the respondents, 89 percent female and 84 percent male decision makers were of the opinion that summer season has become hotter in their area than it was 20-30 years ago.

The Climate Impact Survey, 2013 provides information regarding gender specific perceptions about climate change such as change in temperature, precipitation, and other climatic factors. In order to know whether the perception about climate change are independent of gender or not, we applied chi-square test for independence of attributes. The results are suggestive that the gender specific perceptions about overall rainfall and joint change in summer and rainfall differ significantly rejecting the null hypothesis that climate change perceptions and gender are independent; whereas for change in summer seasons the null hypothesis is accepted which implies that perception about summer changes does not depend on gender.

Table 5

Perceptions of Male and Female Decision Makers about Climate Change

Climate Factors	Male (%)	Female (%)
Overall Rainfall Increased	33.66	31.93
Overall Rainfall decreased	59.36	62.85
Summer Season More Hot	84.04	88.88
Summer Season Less Hot	11.44	9.08
Jointly Rainfall & Summer Change	89.53	93.06

Results of Chi-square Test:

Pearson Chi2 = 0.0766 P-value = 0.782: for summer change
Pearson Chi2 = 13.3146 P-value = 0.000: for Overall Rainfall change
Pearson Chi2 = 5.4124 P-value = 0.020: for Joint change in summer and overall rainfall

Average Vulnerability Index Gender wise

A composite vulnerability index has been generated on the basis of six sub-indices such as socio-demographic index, social networking vulnerability index, livelihood vulnerability, food vulnerability, health vulnerability, and climate variability index by using PCA. Values of this vulnerability index range from -0.5 to +10.5 where higher values show higher vulnerability. Positive values indicate higher vulnerability and these households have poor adaptive capacity and the nearer the value of vulnerability to 10, the highly vulnerability prevails among respective households and negative values are indicating less vulnerability which is showing these households are vulnerable but they can take themselves out of adverse shock, signifying that these households have much better adaptive capacity Opiyo, *et al*. (2014).

The mean score of the overall vulnerability and the constituent sub-indices are calculated for various categories of households by selected indicators/factors including decision making (role by gender), age of male head of the household, tenancy status, and certain gender differentiated variables like earning of non-farm income by females, family females are given right of inheritance, and females' participation in social events etc. The results support that those families where females are empowered (play role in decision making, earn non-farm income, participate in social events, can visit hospital/doctor for treatment) and are given right of inheritance in property are in the overall less vulnerable (see Table 6). Moreover, it is observed that mean score of livelihood vulnerability, health vulnerability, and food vulnerability are positive and high reflecting high prevalence of these vulnerabilities among all household groups based on gender differentiated indicators. However, it can be observed that scores are smaller for families where females are empowered showing that those families where females are empowered are relatively less vulnerable in terms of food, livelihood, and health vulnerability.

Table 6

Mean scores of Vulnerability Indicators for various Groups of Households

Indicators	Indicators of Vulnerability Indices					
	Overall	Health	Livelihood	Social network	Food	Socio-Demographic
Decisions:						
By male only	.0036661	.4391162	1.482822	-.0837054	.1712906	-.0929796
By female only	-.0864133	.3985751	1.504502	-.0826435	.1596765	-.2543254
By both	-.0300145	.4132685	1.508680	-.0774357	.163127	-.1554641
Age Groups:						
15-25 years	.0115401	.4237008	1.465432	-.0754774	.1621546	-.1112086
16-40 years	.0424275	.4457962	1.468411	-.0917449	.1682556	-.0435679
41-60 years	.0072418	.4342225	1.499321	-.0730595	.1723434	-.080423
Over 64 years	.0116027	.4382416	1.504884	-.0834224	1.323658	-.0940418
Tenancy:						
Owner	-.0078109	.4290161	1.492049	-.0889222	.7854636	-.1361509
Owner-cum-Tenant	.0358131	.4207821	1.416006	-.1664096	.1715625	-.0698803
Tenant	.0839007	.4724986	1.539762	.0059873	.1919819	.083085
Non-farm Income:						
Female	-.0120114	.4194858	1.522916	-.0654110	.160153	-.1350212
Male	-.002826	.4450051	1.525307	-.0643084	.1650904	-.1085653
Female social participation	-.0425006	.398825	1.512166	-.1033539	.1532353	-.1980291
Females' entitlement to inheritance	-.1541897	.3906136	1.499315	-.0851432	.1507105	-.4581359

The mean scores of various vulnerability indicators by age group of the male head of the household show prevalence of high vulnerabilities except the social network and socio-demographic vulnerabilities. The families, headed by males older than 60 years, have the highest food vulnerability whereas the other groups have comparable score for food vulnerability. The families having the youngest household heads (15-25 years) have relatively higher overall and socio-demographic vulnerability than the others. The mean scores of vulnerability indices are also disaggregated by tenancy status of the farmers. It was observed that the tenants are more vulnerable than the owners and owner-cum-tenants in terms of all vulnerability indices except the food vulnerability. Interestingly, the owner farmers were observed to be most food insecure. On the whole, sampled households are highly vulnerable in terms of food, health and specifically in terms livelihood strategies. This reflects poor adaptive capacity of the famers and need due attention of the relevant authorities to support them in case of climatic and other natural shocks.

District wise Mean Vulnerability

The mean scores of various vulnerability indices were also calculated by district and the results are reported in Table 7. The results are suggestive that in terms of overall vulnerability index; Sanghar, Larkana, Mirpurkhas, Jhang and Bhakar districts are the most vulnerable out of the sixteen sampled districts whereas Vehari, Bahawalpur, Charsada, and Nwabshah are also vulnerable districts in terms of overall vulnerability. Rest of the districts i.e. Sialkot,

Hafizabad, Chakwal, Haripur, Kohat, Attock, and D.I. Khan are less vulnerable as compared to rest of the sampled districts. Further, all the sampled districts are found highly vulnerable in terms of health vulnerability index, livelihood, and food vulnerability indices. In term of livelihood strategies, all districts are highly vulnerable but especially Haripur, Larkana, and Sialkot are the most highly vulnerable districts. District Attock is found to be the most highly vulnerable district in terms of food vulnerability; although, all districts are found highly vulnerable in terms of food vulnerability.

Table 7

Mean scores of Vulnerability Indicators by Districts

	Indicators of Vulnerability Indices					
Districts	Overall	Health	Livelihood	Social Network	Food	Socio-Demographic
Bahawalpur	0.0602351	0.361903	1.424679	-0.25085	0.167670	-0.091220
Vehari	0.0769975	0.351970	1.442890	-0.29505	0.154341	-0.013910
Jhang	0.1204795	0.501943	1.389553	-0.06205	0.156004	0.058986
Bhakkar	0.1024377	0.535471	1.377474	-0.08222	0.174116	0.033043
Sialkot	-0.1910026	0.310156	1.589351	-0.17207	0.129821	-0.391990
Hafizabad	-0.0998851	0.318375	1.445969	-0.24627	0.137210	-0.309970
Chakwal	-0.1062231	0.410995	1.421163	0.01136	0.132443	-0.302230
Larkana	0.1465415	0.483257	1.641604	-0.05798	0.207995	0.131892
Nawabshah	0.0935659	0.469509	1.476141	-0.04802	0.186351	-0.030110
Mirpurkhas	0.1036709	0.446541	1.538954	-0.08195	0.155051	0.096847
Sanghar	0.1492061	0.471715	1.533933	-0.13376	0.169101	0.155346
Haripur	-0.1815799	0.436399	1.700177	0.12580	0.169338	-0.322330
Charsada	0.0602557	0.465011	1.366096	-0.06094	0.193859	0.179079
Kohat	-0.0048051	0.512277	1.508891	0.014074	0.200232	-0.066140
Attock	-0.0400953	0.443151	1.548145	0.063779	0.310033	-0.197530
D.I. khan	-0.0017254	0.491862	1.443203	0.009837	0.210316	-0.09220

Empirical Results

Determinants of Overall Vulnerability

The paramount concern of this study is to construct vulnerability index and finding its determinants including the gender differentiated factors. As described earlier, we have categorised vulnerability index into three categories namely high vulnerability, moderate vulnerability, and less vulnerability however, only two categories were found as highly vulnerable and less vulnerable. High vulnerability category is assigned a value equal to two (2) and less vulnerability, a value equal to one (1). We estimated the ordered logit model to find out determinants of vulnerability. The explanatory variables included family members in age groups 15 years or below, 16-30, 31-40, 40-60 and above 60 years, ratio of females in family, ratio of educated females to total females in a family, dummy variables (representing entitlement rights of females to

inheritance, females permitted to participate in social ceremonies, non-farm income earning participation of male and female in decision making related to agriculture access to credit, and tenancy status of farmers), farming experience, distances to boys and girls schools, distance to basic health unit, and climatic factors (20 years averages of Rabi and Kharif season temperature and precipitation and deviations of the climatic factors from long run mean. The results of ordered logit model are given in Table 8. The overall results show that the model is a good fit. The families with more middle-aged members (31-40 years age) are found significantly less vulnerable as compared to families that have more older members (>60). Further, female ratio to total family members and ratio of educated females to total number of females in a family are found statistically insignificantly affecting vulnerability of farm households.

The results show that the tenants are significantly less vulnerable compared to the owner operators; whereas the owner-cum-tenants are significantly more vulnerable as compared to the reference category of owner farmers. The families with greater farming experience were found more likely to be highly vulnerable because of their association with old farming practices.

The results regarding gender differentiated variables such as households where females are given right of entitlement to inheritance are more likely to be highly vulnerable and the families where females can go outside house and visit to hospitals are less vulnerable than those households where females are restricted to their house. Interesting implication of these findings is that even females are given property rights but they are not allowed to move outside the family alone are more likely to be highly vulnerable. Moreover, those households where only male members are earning non-farm income and females are not allowed to participate in non-farm income activities are also significantly more likely to be highly vulnerable. Similarly, families where only male household heads have the power to make decision about family matters and agriculture related activities are significantly more likely to be highly vulnerable. Results from gender differential variables make it evident that those families where females are empowered are more likely to be less vulnerable as compared to the male dominant households.

The households having access to loan are more likely to be less vulnerable than those households which do not have loan access. Interestingly, those households which tell they received government support are more likely to be highly vulnerable. The reason may be that government help seeking households are already highly vulnerable that's why they pursue help from government. Further, the result is indicative of the fact that the support is insufficient to have an impact on vulnerability of the households. Infrastructure variables are found insignificantly affecting the overall vulnerability categories such as distance of boys and girls primary schools and rural basic health units.

Table 8

The Coefficient Estimates of Ordered Logistic Regression

Ordered logistic regression	Number of obs = 3427			
	Wald chi2(28) = 158.90			
	Prob > chi2 = 0.0000			
Log pseudo likelihood = -333.69175	Pseudo R2 = 0.4528			
Vulnerability overall	Coef.	Robust Std. Err.	Z	P>z
Female ratio	-0.1063500	0.7174084	-0.15	0.882
Female education ratio	0.2113589	0.3194047	0.66	0.508
Family Composition by Age Groups				
≤15 years	-0.0816699	0.0624167	-1.31	0.191
a16-30 years	-0.0896724	0.0550423	-1.63	0.103
31-40 years	-0.1862133	0.0883179	-2.11	0.035
41-60 years	-0.1224510	0.1390007	-0.88	0.378
> 60 years	Reference category			
Farm Categories by Tenancy:				
Tenant	-0.4617599	0.2211838	-2.09	0.037
Owner-cum-tenant	0.7134739	0.3577705	1.99	0.046
Owner	Reference category			
Other Socio-economic variables:				
Females' Entitlement to Property	0.7623029	0.2657722	2.87	0.004
Women allowed treatment	-0.8407179	0.2181734	-3.85	0.000
Male non-farm income	0.9030388	0.2234611	4.04	0.000
Female non-farm income	-0.1433459	0.3090150	-0.46	0.643
Farm experience	0.0165924	0.0093453	1.78	0.076
Decision male domestic	0.4763890	0.2279679	2.09	0.037
Decision female domestic	0.1398013	0.2915697	0.48	0.632
Loan access	-5.3064480	0.7534259	-7.04	0.000
Government Help	3.7417560	1.0122580	3.70	0.000
Distances:				
Distance to girls primary school	-0.0169685	0.0228792	-0.74	0.458
Distance to boys primary school	-0.0627094	0.0665511	-0.94	0.346
Distance to basic health unit	0.0084404	0.0180059	0.47	0.639
Climatic Factors				
Rabi_20 temperature	0.0962953	0.2627532	0.37	0.714
Kharif_20 temperature	0.3586750	0.3389424	1.06	0.290
Deviation_kharif20_precipatation	-0.0066039	0.0115432	-0.57	0.567
Deviation_rabi20_precipatation	0.0187723	0.0120018	1.56	0.118
Deviation_kharif20 temperature	1.2821900	0.3292278	3.89	0.000
Devaition_rabi20 temperature	0.5540916	0.3936391	1.41	0.159
Kharif20_precipitation	0.0402703	0.0175359	2.30	0.022
rabi_y20_precipitation	0.0538961	0.0203977	2.64	0.008
/cut1	4.603369	6.120731		

Finally, it is found that climatic variables are causing more vulnerability among farm households through livelihood vulnerability, food, health, and social vulnerability. Results are suggestive that greater deviation of Kharif season temperature from its long run norm enhances the vulnerability of the farming households. Similarly, increase in long run norm of the precipitation (Kharif as well as Rabi) enhances the household level of vulnerability.

Determinants of Health Vulnerability

This study also examined the determinants of health vulnerability by estimating regression equation using ordinary least squares (OLS) method. We have regressed health vulnerability (a continuous variable) on explanatory variables including variable representing family composition by age groups and gender; ratio of educated females in the family, variable showing entitlement of females to inheritance, females are allowed to participate in any social ceremony, male and female having non-farm participation, male and female decision making in agriculture related matters, dummy variables representing tenancy status distances to important institutions (schools and basic health units), other socio-economic variables and climatic factors (temperature and precipitation). In the overall, the estimated model is a good fit with highly significant value of F-statistics and an R^2 of 0.64. The estimated coefficient and P-value are reported in Table 9.

The results are suggestive that household with higher number of younger family members are more health vulnerable as the coefficient of both the younger age groups (≤15 years and 16-30 years) are positive and highly significant. Further, tenancy status plays an insignificant role in determining health vulnerability. The farming experience is also found affecting health vulnerability insignificantly.

The farm households which have higher female ratio in their families are found more health vulnerable whereas the household with greater ratio of educated females in the family are less health vulnerable as compared to those which have low literacy among the female members. Further, females having right of entitlement to inheritance are found less health vulnerable. Similarly, the households which have females earning non-farm income and which allow their female members' participation in social activities are also found less health vulnerable.

Role of females in decision making regarding family and agriculture related matters turned out to be an important determinant of health vulnerability and this decision making role of female members reduces health vulnerability.

The access to loan has a negative but has slightly significant impacts on health vulnerability and is suggesting that those households which have loan access are less vulnerable but these impacts are not highly significant. Further, government assistance is also found as an insignificant determinant of health vulnerability.

The rural infrastructure variables (distances to girls and boys primary schools and basic health units) are related to health vulnerability positively and significantly suggesting that the larger distance involved to the educational institutions and health facilities, the higher would be the health vulnerability. Finally, impacts of climatic factors are observed and the results suggest that almost all climatic factors except Rabi season deviation of precipitation are

Table 9

OLS Estimates of Health Vulnerability Regression

Linear regression Number of obs = 3427
F(28, 3398) = 55.01
Prob > F = 0.0000
R-squared = 0.6426
Root MSE = .10772

Health vulnerability	Coef.	Robust Std. Err.	T	P>t
Family Composition by Age Groups				
≤15 years	0.009088	0.0011573	7.85	0.000
16-30 years	0.003622	0.0010622	3.41	0.001
31-40 years	0.000150	0.0019472	0.08	0.938
41-60 years	-0.002403	0.0024686	-0.97	0.330
> 60 years	Reference category			
Female Ratio	0.026665	0.0140007	1.9	0.057
Female education ratio	-0.044585	0.0061007	-7.31	0.000
Farm Categories by Tenancy				
Owner	Reference category			
Tenant	-0.005741	0.0049835	-1.15	0.249
Owner-cum-tenant	0.004218	0.0051966	0.81	0.417
Other Socio-economic variables				
Property rights female	-0.041614	0.0044804	-9.29	0.000
Female social participation	-0.020094	0.0047342	-4.24	0.000
Male-non-farm	0.022476	0.0039355	5.71	0.000
Female-non-farm	-0.013432	0.0054483	-2.47	0.014
Farm-experience	0.000043	0.0001481	0.29	0.771
Decision-male-domestic	0.026478	0.0045918	5.77	0.000
Decision-female-domestic	-0.026071	0.0048118	-5.42	0.000
Loan access	-0.006570	0.0040943	-1.61	0.108
Govt. help	0.006806	0.0056230	1.21	0.226
Distances				
Girls primary school	0.001054	0.0004952	2.13	0.033
Boys primary school	0.003425	0.0014988	2.29	0.022
Basic health unit	0.003264	0.0003192	10.23	0.000
Rabi_20 temperature	-0.033706	0.0039753	-8.48	0.000
Kharif_20 temperature	0.041703	0.0046292	9.01	0.000
Deviation_khrf20_precipatation	0.000344	0.0001907	1.81	0.071
Deviation_rabi20_precipatation	0.000242	0.0002749	0.88	0.377
Devition_kharif20 temperature	0.017176	0.0057662	2.98	0.003
Devition_rabi20 temperature	0.061849	0.0058304	10.61	0.000
Kharif_y20_precipitation	-0.000754	0.0000966	-7.82	0.000
Rabi_20_precipitation	0.001040	0.0002218	4.69	0.000
_cons	0.138604	0.0622485	2.23	0.026

important determinant of the health vulnerability; and all the climatic variables enhance household level health vulnerability except the long run norm of the Kharif precipitation and Rabi-temperature which reduces health vulnerability.

Determinant of Food Security

This research also investigated gender differentiated factors which affect food security and for empirical purpose, the food security index (constructed in earlier part of the paper) has been regressed on variables which are used in aforementioned regressions by using Logit Model. The results suggest that the households which have more family members in age groups that are younger as compared to age group of older above 60 years (the reference age group) are more food secure (see Table 10).

Table 10

Estimate of Food Security from Logistic Regression

Logistic regression	Number of obs. = 3427			
	Wald chi2(25) = 617.83			
	Prob. > chi2 = 0.0000			
Log pseudo likelihood = -1823.895	Pseudo R2 = 0.2256			
Food security	Coef.	Robust Std. Err.	Z	P>z
Family Size	0.2023540	0.0271855	7.44	0.000
Female Ratio	0.1019771	0.3069179	0.33	0.740
Female Education Ratio	0.3139405	0.1286285	2.44	0.015
Family Composition by Age Groups				
≤15 years	0.0465162	0.0375336	1.24	0.215
16-30 years	0.2260166	0.0393413	5.75	0.000
31-40 years	0.3249264	0.060555	5.37	0.000
41-60 years	0.1844940	0.0609359	3.03	0.002
> 60 years	Reference category			
Farm Categories by Tenancy				
Tenant	0.0190866	0.1114146	0.17	0.864
Owner-cum-Tenant	-0.6373200	0.1152624	-5.53	0.000
Owner	Reference category			
Other Socio-economic Variables				
Entitlement of females to inheritance	0.3356248	0.0954207	3.52	0.000
Female social participation	0.1158763	0.1051698	1.1	0.271
Male non-farm income	0.0260516	0.0866276	0.3	0.764
Female non-farm income	-0.0892336	0.1212362	-0.74	0.462
Farm experience	0.0120486	0.0033407	3.61	0.000
Decision by only male (domestic matters)	0.0231248	0.1006512	0.23	0.818
Decision by only female (domestic matters)	-0.1658156	0.1020220	-1.63	0.104
Loan access	0.1497902	0.0909458	1.65	0.100
Govt. help	-0.1239031	0.1170514	-1.06	0.290
Human health center	-0.0112345	0.0067003	-1.68	0.094
Climatic Factors				
rabi_20 temperature	-0.0817382	0.0829224	-0.99	0.324
Kharif_20 temperature	0.0648475	0.0917181	0.71	0.489
Deviation_kharif20_precipatation	0.0155591	0.0040916	3.8	0.000
Deviation_rabi20_precipatation	0.0079300	0.0048384	1.64	0.101
Deviation_kharif20 temperature	0.1574168	0.1266443	1.24	0.214
Deviation_rabi20 temperature	-0.2905540	0.1165672	-2.49	0.013
_cons	-5.8515980	1.2345330	-4.74	0.000

The results show that family size and literacy among female members of the household are important determinants of the food security both affecting it positively and significantly. However, the composition of family by gender (female ratio) is not an important determinant of household food security.

The results show that owner-cum-tenants are less likely to be food secure as compared to owner farmers. The access to loan is another important determinant of food security and the households having access to loan are more likely to be food secure. The support received from government as assistance has an insignificant effect on household food security.

As far as the effect of gender differentiated variables on food security is concerned, it is found that entitlement of family females to inheritance enhances likelihood of household level food security. However, only those households which give inheritance property rights to their females are found more food secure and these results are highly significant. Whereas, households where a female has dominancy in decision making is found more food secure as compared to those households which have male dominancy. Rest of the variables, such as female participation in social gatherings and events, and male and female non-farm participation are found statistically insignificant. On the whole, we can say that households where females are empowered are more food secure than those where females are not empowered.

Finally, deviation of Rabi temperature from the long run norm and that of Rabi precipitation and Kharif precipitation have statistically significant effect on food security. The deviation in Rabi temperature has the adverse impact on food security as it affects wheat productivity a staple food in Pakistan. The precipitation deviations in both the seasons have a positive impact on food security.

IV. SUMMARY AND CONCLUSION

This research explores the impact of climate change and gender differentiated socio-economic factors on household vulnerability. The study is based on the Climate Change Impact Survey (CCIS), 2013 data collected from 3430 farm households located in 16 districts of Pakistan representing all the major cropping systems and various categories of farms by tenancy and size of operational holding. The vulnerability index is constructed by combining six sub-indices normalised between one and zero through Principal Component Analysis (PCA) whereas the food security index was constructed by combining (through PCA) non-normalised sub-indices covering two important components of food security namely availability and accessibility. The study estimated ordered logit model to examine the impact of climatic factors and gender differentiated impacts of various socio economic variables on household vulnerability. The results of descriptive analysis are suggestive that in terms of overall vulnerability index; Sanghar, Larkana, Mirpurkhas, Jhang and Bhakar are the most vulnerable districts out of the sixteen sampled districts. The results support that households with greater empowerment of the females are less vulnerable. The composition of family by age group turned out to be an important determinant of overall vulnerability. The families with more middle aged members (31-40 years) are found significantly less vulnerable as compared to families that have more older members (>60). Further, the composition

of family by gender and literacy among females are less important determinants of overall vulnerability. The climatic factors special deviations in Kharif season temperature for the long run norm enhance the vulnerability of the farm households. Similarly, increase in long run precipitation in Rabi as well as in Kharif leads to higher vulnerability of the households.

The results regarding health vulnerability regression model are suggestive that family composition by gender and age as well as literacy among females are important determinants of health vulnerability. It is observed that the households with higher number of younger family members are more health vulnerable. The farm households which have higher female ratio in their families are found to be more health vulnerable; whereas the households with greater ratio of educated females in the family are less health vulnerable. Finally, the results suggest that almost all climatic factors except Rabi season deviation of precipitation are important determinant of the health vulnerability and all the climatic variables enhance household level health vulnerability except the long run norm of the Kharif precipitation and Rabi-temperature which reduces health vulnerability.

The results of binary logit model estimated for food security are suggestive that family size and literacy among female members of the household are important determinants of the food security both affecting it positively and significantly. However, the composition of family by gender (female ratio) is not an important determinant of household food security. Finally, deviation of Rabi temperature from the long run norm and that of Rabi precipitation and Kharif precipitation have statistically significant effect on food security. The deviation in Rabi temperature has the adverse impact on food security as it affects wheat productivity, a staple food in Pakistan. The precipitation deviations in both the seasons have a positive impact on food security.

APPENDIX

Appendix Table 1

Animal Type	Age and Sex Composition	Weight
Buffaloes	Buffaloes in milk	1.50
	Buffaloes (dry)	1.20
	Heifer Buffaloes	0.60
	Young stock (Buffaloes)	0.30
	Male Buffaloes	1.20
Cow	Milking Cow	1.00
	Breeding Cow	1.00
	Heifer Cow	0.40
	Young stock Cow	0.25
	Dry Cow	0.80
	Bullocks	1.20
Goat and Sheep		0.25
Camel		1.50
Horses		1.00
Donkeys		0.50

Appendix Table 2

Definitions of Major Components and Sub-Components of Vulnerability Index

Major Components	Sub-Components or Indicators
Socio-Demographic Profile	**Dependency ratio**: sum of age group below 15 years and above 64 years divided by working age group 15-64 years old **Female ratio**: total number of female divided by family size **No education:** Number of family members above age 14 years of household members having primary education **Female primary School Distance:** Distance of female primary in KM from village **Male primary School Distance:** Distance of male primary in KM from village **Female inheritance:** if female have no right to have share in inheritance property then it is assigned 1, otherwise zero.
Livelihood Strategies	**No non-farm income**: households having no non-farm income are assigned 1, otherwise zero. **Crop diversification:** Hefindahl index will be used to calculate crop diversification and it is the sum of squares of the acreage proportion of each crop in total cropped area. After calculating it, index of this index is taken. Where values of index ranges between 1 and 0 and values nearer to 1 shows lower diversification. **Livestock holding:** A cow equivalent score has been generated which shows livestock holding but for vulnerability, we took inverse of it. **Land size**: land size is in acre which indicates the higher land size, the higher level of income can be but for vulnerability index, inverse of it has been taken.
Social Networks	**Average help receive to help give ratio**: Help receive in agriculture and other sides is dived by help given (informally) **No-access to loan:** A dummy variable where 1 is for not access and zero for having access of formal loaning. **Distance of extension:** distance of extensions from village in Km. **Assistance from Government:** A dummy variable where 1 is for having no assistance from local, provincial and federal governments, and zero for assistance received.
Food Vulnerability	**Average number of months households struggle to find food:** Households reported they have faced difficulties in respective number of months divided by 12. **Food Supply sources:** A score has been generated where food sufficient is zero vulnerable, depend on sale of livestock and livestock products, mainly buy from markets, and get from exchange for labour, and mainly borrow from neighbour and a score ranging from zero to five. The higher the value, the higher vulnerable a household is. **Daily per person calories intake:** Food consumption in gram is multiplied by kilo calories in respective commodities. For vulnerability index, inverse of it has been taken where the higher value indicates higher vulnerability.
Health Vulnerability	**Sources of drinking water**: Piped water, motor pump, hand pump, covered well, and open well where score has been generated ranging between 1 and 5. Higher values indicate higher water vulnerability which ultimately affects human health. **Type of toilet**: Types of toilet i.e. flush public sewerage, flush with pit, open drain, dry latrine, and no toilet where score has been generated ranging between 1 and 5. Higher values indicate higher vulnerability which ultimately affects human health. **Total number of ill members**: Total male, female, and children members of household who suffer from diseases. **Ratio of treated members to total ill members:** Number of household members get treated or having treatment divided by the total number of ill members. **Females are allowed to visit dispensary:** A dummy variable if females are allowed to visit dispensary=1, otherwise zero **Distance of basic rural health centres:** Distance of basic rural health centres in kilo meters from village
Climate Variability	**Average Temperature**: 20 years average temperature of Rabi and Kharif **Average Precipitations**: 20 years average precipitation of Rabi and Kharif **Temperature Deviation**: Last twenty years deviation in Rabi and Kharif **precipitations Deviation**: Last twenty years deviation in Rabi and Kharif

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This series of papers is an outcome of a joint research project of PIDE and IDRC. Transnational financing of developmental projects by donor agencies has emerged to be a notable phenomenon around the globe. Amongst others, International Development and Research Centre (IDRC) Canada remains one of the leading agencies providing funds for multifaceted developmental projects being implemented in developing countries. The project ***"Climate Change Agriculture and Food Security in Pakistan: Adaptation Options and Strategies"*** is one such an endeavor of PIDE and IDRC. Broadly speaking, the project aims at exploring responses of crop yields to changing climate and analyzing the adaptation efforts undertaken by farmers. The issue of climate change bears a special importance for Pakistan's economy being heavily dependent on agriculture sector both in terms of its contribution to GDP and employment. This project involves two strands of empirical undertakings: i) studies based on districts-level panel; and ii) studies based on Rapid Rural Appraisal (RRA) and household level survey data. The outcomes of the studies based on panel and cross-sectional data are being reported in working paper series of the project whereas findings of RRA have been published as a policy brief. However, for information of readers, the salient upshots of RRA are summarized in the following.

The evidence from RRA is suggestive that the farming communities in various regions of Pakistan widely perceive that climate is changing and is adapting accordingly through undertaking a wide range of adaptation strategies. Some of the adaptations in rainfed areas include use of deep tillage for rainwater harvesting and preserving moisture, building of small check dams, shifting away from shallow rooted to deep rooted crops, and delayed sowing of wheat and mustard by 15-30 days etc. While adaptations in irrigated agriculture include, in major, increased installation of tube-wells, increased area under low-delta/low-input requiring crops like canola and mustard as alternative to wheat in water scarce areas and substitution of other crop (guar seed and cotton crops being replaced with mungbean in low intensity zone), delayed wheat sowing by 15-21 days, and sowing of cotton on ridges to manage water scarcity etc.

Surprisingly, however, notwithstanding the changing climate, the research institutions and extension department still keep recommending completion of wheat sowing by 20th of November irrespective of regional climate variations. The sowing of rice nursery before 20th of May is prohibited according to the Punjab Agricultural Pest Ordinance, 1959 in order to control multiplication of harmful pests on early sown rice nurseries. Further, canal closure schedules do not match with the adaptation needs of farmers confronting climate changes (especially wheat in Punjab and rice in Sindh. The farmers have an urgent need of support from agricultural research and extension as well as other government departments to enhance their adaptive capacities.

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